Maintaining Drainage Systems

U. S. DEPARTMENT OF AGRICULTURE

Farmers' Bulletin No. 2047

COMPLETE *soil and water conservation means the best use of the land. Some wet land is used best when you grow trees or wildlife on it. You cannot use your wet crop and pasture land to the best advantage if your drainage system does not work right. Soggy, wet conditions force you to use your fields for less than highest possible production—either because you plant a different crop or because the yield isn't as high as it should be. In either case you lose. If poor drainage of your bottom-land fields forces you to plant crops on the slopes, you suffer a double loss: You do not benefit from the full productive power of the lowland, and hillside planting is likely to cause more erosion on the sloping fields.*

Many drainage systems fail because of poor maintenance. It is estimated that at least 30 million acres of existing farm-drainage systems need better outlets. Much of that problem would have been solved by proper maintenance in the past. Drainage ditches filled with debris or silt, clogged outlets, tile outlets undercut by erosion, and other problems are results of not doing needed maintenance work year by year.

At least a fourth of the cropland of the United States is in some kind of drainage enterprise. That emphasizes the importance of effective maintenance, which is important not only to the individual producer but also to the Nation's total supply of food and raw materials.

This bulletin describes methods of maintaining drains and discusses the importance of planning for such work.

Issued October 1952 Washington, D. C.

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MAINTAINING DRAINAGE SYSTEMS

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A farm drainage system is not something you can install and forget. You need to watch it and take care of it. If you fail to do so, your outlet channels, ditches, or tile may soon become so clogged as to be almost useless (fig. 1).

You should keep ditches reasonably clear of weeds, silt bars, and rubbish. Any of these can make them stagnant pools instead of water-disposal channels. You must watch to see if your tile drains have become clogged and thus are failing to drain your fields (fig. 2).

You may even need to completely overhaul or revise the system you now have to get efficient results. Many good but costly drainage systems do not work because of lack of maintenance.

Moreover, when outlet ditches serving a large drainage enterprise are neglected, damages do not occur equally over the whole area. The lower land is damaged first. Crop losses may be heavy for several years on low-lying land while higher land is relatively free from damage. The poorly drained land is not able to bear its share of drainage assessments. The burden of maintenance then falls on the higher land. Thus, it is far better for the maintenance work of a drainage enterprise to be carried on as an annual affair.

Poor maintenance is often evident

Figure 1.—Because of poor maintenance of an open ditch system, part of this field is not producing as much as it could and some is not producing at all.

when you travel on highways or railroads through drained areas. You see channels overgrown with brush, weeds, and small trees. You also see ditches filling with sediment. Most of this sediment comes from eroding land, an unprotected inlet, or an unprotected bank.

In fact, many systems have been neglected for so long that it will pay to have them redesigned and reconstructed in accordance with conservation principles and to establish the kind of rotations and soil-building practices that are so essential to conservation farming.

If your outlet ditches have silted up or if tile outlets are covered, you probably need deeper and larger outlet ditches. If water stands in your field too long after heavy rains, your whole drainage system needs to be reworked.

Where overhauling of a drainage system is required, you should redesign your system in accordance with modern engineering principles. Farmers' Bulletin 2046, Farm Drainage, gives these principles.

If damage to the drainage system were the only thing to consider, it might be cheaper to forget about regular maintenance and plan for a complete overhauling job at the end of 5 to 15 years. But the annual damages—to crops and to land—that result from poor drainage are likely to be far greater than the damage to the drainage system itself. There are cases where crop losses caused by overflow from a single rain were greater than the cost of an efficient drainage system.

The term "maintenance" as used in this bulletin means annual or regular work that needs to be done on drainage or water-disposal systems. Work that is repeated every few years without altering the basic design is also included. The term "rehabilitation" means a complete reworking of a system. Such work is not covered in this bulletin. The term "drainage enterprise" means an organization to plan, construct, and maintain outlet drains.

FIGURE 2.—Because of stopped-up tile, water stood on this cornfield so long it damaged the crop.

Drainage enterprises nearly always involve two or more landowners. They include drainage districts, county and township drains, and tax ditches, organized under State drainage laws.

Selecting Best Methods of Maintenance

Emphasis in this bulletin is placed on some of the newer and less common methods of maintenance. This has been done to give you details about these methods, not to influence your choice. Final choice of methods should be based on effectiveness, on costs, and on the particular needs of your drainage or water-disposal system. After you have read about these methods you will probably need to ask some questions locally to find out the cost of labor, equipment, and materials needed. Your soil conservation district technician or your county agent will give you help with your problems.

The use of the land adjoining a drainage ditch usually affects your choice of maintenance methods. For example, if a ditch runs a long distance through woodland it may not be

economical to pasture the ditch. It would certainly pay to provide a roadway along one side of the ditch for maintenance work. The best way to keep down vegetation might be by hand labor or it might be by chemicals. Many ditches that run through pastures can be maintained successfully by pasturing. But additional fences may be needed to control grazing. Stock should be kept out of deep ditches when the banks are wet and during freezing and thawing weather.

A few ditches that run through cultivated land may be maintained by pasturing. But usually it is not economical to fence shallow field drains or laterals in cultivated fields in order to pasture. Mowing, burning, chemicals, or hand cutting of vegetation every year and a clean-out with heavy equipment every 3 to 5 years is likely to be more practical. Annual maintenance of shallow drains with a plow or small farm-terrace grader is likely to be economical in cultivated fields.

Preparing and Cultivating Land To Help Maintenance

Good land preparation and methods of cultivation go hand in hand with good drainage maintenance. You can plow and cultivate in ways to get better field drainage and to reduce silting of channels.

In many sections, and particularly in the Southeast, successive cleaning of field drains and plowing toward the drains over a period of years have built up large spoil banks. Some of these spoil banks have become such an obstruction to good farming that it is necessary to spread them so the field will drain readily. Actually, on many farms it would pay to fill old drains having high spoil banks and build new ones.

Some ditches are only partly effective because water from the field collects behind spoil banks in the low spots (fig. 1). To correct this, dig a field drain behind the spoil bank parallel to the main drain to collect the field surface water. To prevent erosion and rapid silting, you will need a pipe, a concrete structure, or a sod flume to drop water from the field to the outlet.

Bedding or Ridging

The usual way to build up beds is to plow with the backfurrow on the

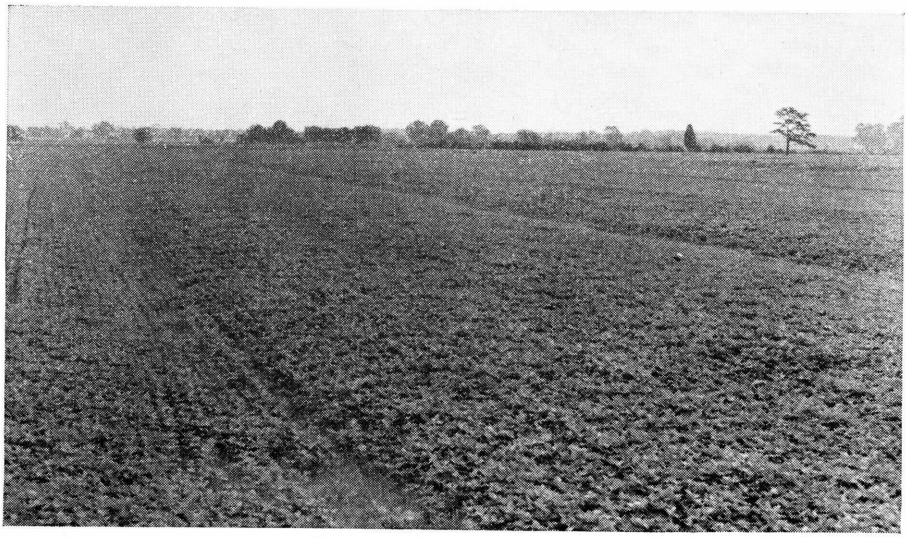

FIGURE 3.—Soybean field in Maryland with well-maintained bedding system.

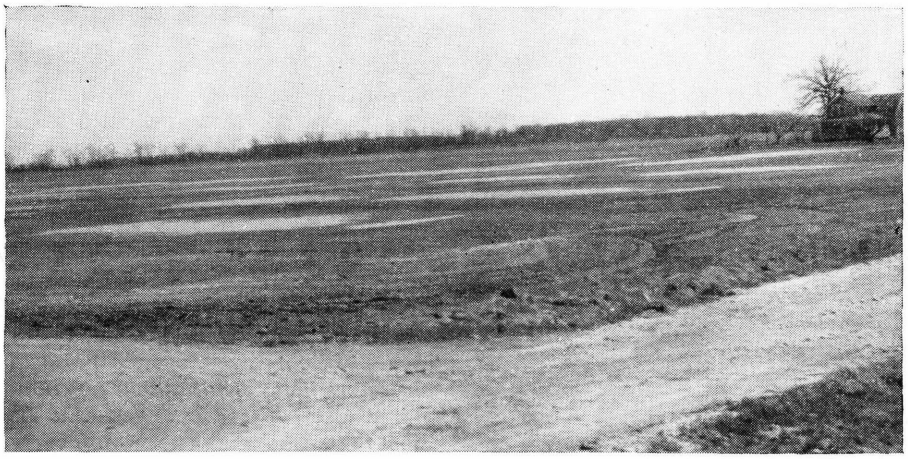

FIGURE 4.—Depressions in this field result in shallow ponds after a heavy rain. Smoothing the land with a land leveler would prevent this.

same location for several successive plowings. To maintain beds, plow most years so as to throw the dirt away from the ditch. Gradually the land is ridged up and the dead furrow acts as an additional surface drain. Most dead furrows need grading and enlargement to make them effective drains. Such work can be done by graders, scrapers, or plows.

This practice is called plowing in "lands" or "bedding." It is used to advantage on fields that are almost level. It is often the best drainage practice on heavy soils that cannot be drained successfully by tile.

Backfurrows are spaced from 30 to 200 feet apart. The ridges are built up from a few inches to as much as 2 feet. The Northeastern Region of the Soil Conservation Service recommends building V-type field ditches using two rounds with a blade grader followed by spoil-bank leveling. Plowing to the center follows to improve field drainage. A view of a field planted to soybeans and treated by bedding is shown in figure 3.

Land Grading or Smoothing

Land grading or smoothing to improve field drainage is sometimes called "land leveling." Such work is needed to correct slight irregularities that cause ponds 1 to 3 inches deep after rains (fig. 4). It is done with heavy equipment such as bulldozers, graders, whirlwind terracers, land planes, or land levelers. Effective work can also be done with farm tractors. This practice is similar to the "land leveling" common in the West for preparing irrigated land. There seems little doubt that it will become more common in the humid areas to obtain more uniform drainage of fields. Results of research indicates it materially increases the yield from sugarcane land in Louisiana.

Often you can fill low spots in fields during annual farming. It may pay to use special equipment such as a land leveler, a float, or a scraper to move dirt from spoil banks, field drains, and high areas into low spots. If the low spots are raised, the field drains do not have to be so deep. Land grading can also be used to advantage on many tile-drained fields. If you remove much topsoil be sure to manure or fertilize the spots heavily to obtain an even field production.

Row Drainage

Many soils and crops require row drainage. Rows must have a uniform grade so as not to collect water. Also, they should not be too long. Cross

FIGURE 5.—A field ditch to collect the water from the crop rows would prevent this ditchbank erosion.

drains are necessary every 400 to 1,200 feet. Low spots may require even closer spacing. Cross drains need maintenance work after the fields are cultivated. It can be done with a plow, but some hand work is often needed.

Rows should not be allowed to run into a deep ditch (fig. 5). They should be collected in a shallow field drain.

Maintenance of Open Drains

To keep surface drainage systems working efficiently, ditches and outlets must be kept open so that water will move freely. Also, erosion must be controlled in the system itself and on the tributary area. The first 2 or 3 years after a system is installed are the most important.

To control bank erosion, vegetation should be established on ditchbanks as soon as possible after they are dug.

Drainage ditches can, however, become choked with vegetation in a short time. In Louisiana, a ditch 15 feet wide and 4 feet deep had only one-tenth its original capacity just 2 years after it was dug. This damage was caused by heavy growth of grasses and indigo.

This, of course, is an extreme case. But weeds, brush, and trees reduce the capacity of many ditches one-half to one-third in 1 to 3 years. Often this means drowned-out crops, since fields are flooded for days. A properly constructed and well-maintained system of farm drains should remove from 1 to 3 inches of surface water in 24 hours on the average, depending on soil, crops, and the rainfall to be expected.

Besides reducing the capacity of ditches, excess vegetation slows down the water. This not only delays drainage; it also causes silt to settle in the ditch. Water moving faster would carry much of the silt through the ditch.

Trees, limbs, fences, and other obstructions also slow down water and start silt bars. Once a small silt bar starts, silt is likely to settle both up and down stream from it.

Silting of drainage ditches should be reduced by control practices at the source of the silt. You can control erosion on your farm land through conservation practices. Often conservation practices can be applied to an unprotected area above a drainage system. You may need to control the banks of the streams flowing into your ditches (see p. 23). If control cannot be provided at the source of the silt, you may need a silt-collecting basin.

Field ditches to collect water from rows in cultivated fields can keep this water from flowing over raw banks (fig. 5) into deep ditches. Where there is an abrupt change in grade from a field to a collecting ditch, take special pains to control erosion. Sod flumes, pipes, or concrete drop structures will give this control.

How Maintenance Affects Design

It pays to spend extra money on the construction of your drainage ditches to reduce maintenance costs. In fact, it is sometimes best to select your method of maintenance first and then design the ditch accordingly. Also, you should plan your row system and field lay-out with drainage maintenance in mind.

In small field ditches and laterals, the kind of equipment you will use for maintenance should determine the shape of each ditch. Often you will use the same equipment for maintenance as for construction.

Wide shallow field drains are essential if you plan to maintain the ditch by plowing or by a small terracer-grader. Side slopes should be 5 to 1 or flatter.

If your ditch is to be maintained by pasturing, side slopes may be as steep as 1½ horizontal to 1 vertical but 2-to-1 side slopes are usually more satisfactory.

If you intend to mow the ditch, side slopes should not be steeper than 4 to 1.

If the field ditches are to be maintained by a machine that straddles the ditch (see fig. 17) a narrow steep-sided field drain is needed.

A wide level berm (fig. 6) makes it easy to move equipment along the bank of a ditch for maintenance work, and it can also serve as a farm road. The other bank may be used for vegetation that provides food and cover for wildlife.

Such a berm can readily be left on a ditch constructed by a dragline. Leveled spoil banks and berms can be cultivated or kept in a hay crop.

Vegetative Cover for Ditchbanks

To establish a cover on your ditchbanks, it is well to plant in the season when the ditch is least likely to run full for about 3 months. Grasses that form a good sod make an ideal cover for the banks of ditches. Under favorable soil conditions such grasses may grow naturally. In some places they need to be planted.

If you plant, first disk the surface. Then apply liberal quantities of lime and a fertilizer having a high proportion of nitrogen, and plant an adapted mixture of seed. Covering the bank immediately after with manure or old straw to serve as a protective mulch is excellent insurance that your seeding will produce a good stand. In spite of careful planning, a heavy flow down the ditch may wash away the seed and mulch. This is a risk that must be taken when planting ditchbanks.

In the Midwest the banks of many outlet ditches are covered by grasses such as bluegrass, redtop, or tall fescues.

On the Eastern Shore of Delaware and Maryland, fescues, lovegrass, and sericea lespedeza are recommended for ditches.

In the Northeast fescues, redtop, and timothy are valuable.

In the South tall fescues, Dallis grass, bermuda, and bahia will stabilize ditchbanks.

Tall vegetation obstructs the flow of water. Reed canary grass, for example, grows too tall and thick for small ditches. Kudzu forms an excellent cover for some of the larger ditches in the South (fig. 7) but is not adapted to most field ditches. It can usually be established by planting crowns on the berm, then fertilizing the plants, and cultivating them for 2 or 3 years.

FIGURE 6.—Wide berm on a Delaware outlet ditch that will be used as a road and for moving equipment.

FIGURE 7.—A curve in a drainage ditch in Tennessee, well protected by kudzu.

Hay crops such as brome and alfalfa are used in many cultivated fields in strips along spoil banks that are leveled.

Ditchbanks as Wildlife Areas

Many ditchbanks and spoil banks can be developed for wildlife. The grass and legume cover on a well-protected ditchbank makes an ideal place for wildlife to live, and food and water are nearby. Fur-bearing animals, game birds and animals, and insect-eating songbirds can all benefit.

In some places a one- or two-row shrub windbreak to prevent winter winds dropping soil from fall-plowed fields into drainage ditches will help maintain the ditch and also furnish food and cover for wildlife. The windbreak can be as much as 100 feet from the center of the ditch, on either or both sides. You can crop the land between the ditch and the windbreak in the same rotation as the rest of the field.

Shrubs suitable for these windbreaks include bush honeysuckle, Persian lilac, autumn olive, and Amur and California privets in the East; caragana, chokecherry, Russian-olive, squawbush, and wild plum in the West. On peat and muck soils, spirea has been successful.

Where possible, do your mowing, grazing, or spraying only after ground-nesting birds have left their nests, usually about grain-harvest time.

Shrubs are not recommended for ditches in cultivated fields except along field borders. Farmers' Bulletin 2035, Making Land Produce Useful Wildlife, gives more information on how to develop ditchbanks for wildlife. Or you can get detailed information from your soil conservation district.

Hand Labor for Clearing Ditches

Hand labor is too expensive to waste. But it takes hand labor to cut and remove weeds and brush on many open ditches. This is often a wet weath-

er or winter job. As a rule, the trash should be burned.

You may need hand labor to remove obstructions or to rebuild fences and water gates to control livestock.

In the early stages of silting, the shoals in ditches are small. Hand labor can easily remove them, especially in smaller drains. On many farms a lot of hand work is needed to clean out field drains and rows soon after a heavy rain. Occasionally hand labor is needed to clean silt from outlet channels and field laterals, but usually other methods are cheaper.

Mowing

Where practical, mowing is a good way to maintain field ditches (see cover). If a ditch is to be maintained by mowing, build it with side slopes flat and smooth enough for tractor operations, and level the spoil banks. For safety of the tractor and driver, the slopes must not be steeper than 4 to 1 if you plan to use a tricycle-type tractor. A flatter side slope of 5 to 1 or even 8 to 1 is better. These flatter side slopes may be necessary if the banks have a tendency to rill, or if small gullies form before vegetation becomes established.

Crossings over deep laterals and extra gates in fences may be needed so that the tractor and mower can work on both banks of the ditch.

Highway-type mowers on which the blade can be dropped or raised 45 degrees make mowing easy on some ditches.

Most banks should be mowed with a farm tractor only during dry weather. If you keep one wheel of the tractor either in the bottom of the ditch or on its berm, the operation usually is easy and safe.

You must decide on a practical way of disposing of cut vegetation before you mow. If there is much growth, it may wash downstream and collect at bridges or culverts. Or it may form bars that trap more trash and silt.

Often such vegetation can be used for hay. It may be practical to use it as a mulch in an adjoining field. Sometimes you may prefer to pile and burn it (p. 11).

Pasturing

Controlled pasturing with cattle and horses has kept many drainage ditches almost free of brush and trees for more than 20 years. Where it can be used, it is one of the most effective and economical means of *maintaining ditches* (*figs. 8 and 9*). But there are many areas where pasturing is not practical.

In the first place, it is not likely to be practical if the field is not fenced. Some ditches should not be pastured because cattle would cause more silting. This usually happens where the soil contains a lot of sand or where grass does not grow well on ditchbanks. You need to study your soil and your farm carefully before you decide to pasture your ditches.

If you do decide to pasture, you

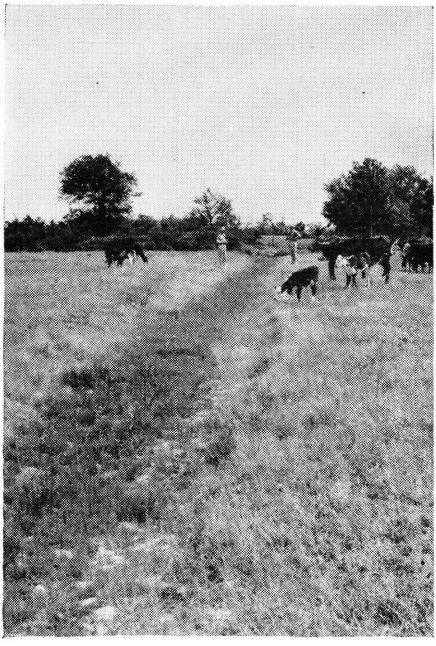

FIGURE 8.—A field drain maintained by grazing as part of a larger pasture.

may want to plant grasses on side slopes and banks as soon as possible after digging, both to get good pasture and to reduce erosion. Where grasses come in rapidly without planting, however, seeding may not pay. You can get information on the methods, kinds of grasses, rates of seeding, and lime and fertilizer needs from your soil conservation district or your county agent.

In many places it is worth while to broadcast a cover crop such as oats or rye just after digging the ditch. The banks are moist and the plants soon form a mulch. Perennial grasses may be seeded either with the grain or later, depending on the season.

Even though you pasture your ditches, usually you need to mow the weeds and brush to maintain a good grass sod. If willows cause trouble, intense pasturing when the sprouts are starting in the spring will help keep them under control. Chemical treatment or mowing may also be required.

Temporary electric fences may provide the fencing necessary. In some places, fencing can make it possible to include ditches as parts of a larger pasture.

Stock should not be allowed to overgraze ditches. They should be kept out whenever the soil is saturated and during freezing and thawing weather. *Keep hogs out of deep ditches at all times.* They root the vegetation on the banks and cause erosion.

If hogs are to get water from a drainage ditch, you may need a special water hole for them. While digging the ditch you can build one cheaply. Sometimes a water hole can be located at a junction of ditches and serve as a silt-collecting basin as well as a water hole. It should be fenced off from the ditch.

To make it easy for cattle to get in and out of a ditch with steep banks, you may dig ramps or inclines. The ramps should have a 3-to-1 or 4-to-1 slope and be 6 to 10 feet wide. Their purpose is to allow easy access and reduce ditchbank erosion. Ex-

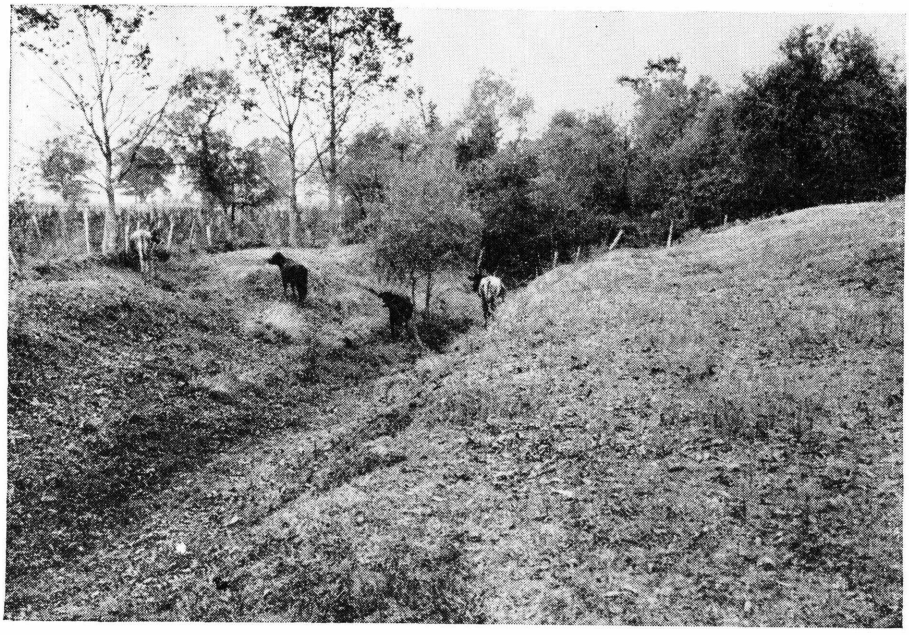

FIGURE 9.—The drainage ditch on this side of the fence is well maintained by pasturing. Brush and small trees are filling the ungrazed part beyond the fence.

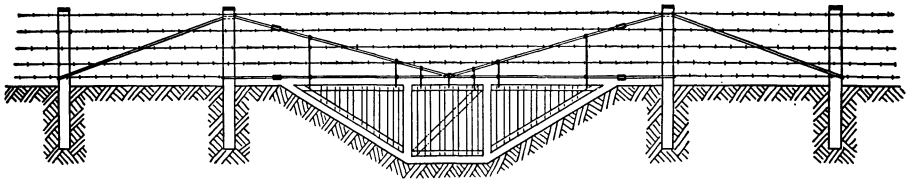

FIGURE 10.—A three-section swinging water gate hung from a cable that can be tightened if the gate sags.

perience shows that cattle will use a ramp instead of climbing down a steep ditchbank. If the ramp erodes, the bottom of the ditch can be widened a few feet at the ramp to provide a silt-collecting area.

Wherever a fence crosses a ditch a gate should be hung at the bottom of the fence to keep livestock from passing under (fig. 10). These water or flood gates can be hung on a cable or a beam. Then during high water the gate will swing open and permit trash and floodwaters to pass. It should close when the water in the ditch recedes.

Often the managers of drainage enterprises can arrange with farmers to pasture public drainage ditches. But where small ditches run through cultivated fields, pasturing is not recommended. Also it is not usually advisable to graze ditches located through woodlands.

Burning Undesirable Vegetation

Quick burns in winter or early spring, when the ground is frozen or wet, have long been used to keep down brush and weeds in the Midwest and other areas. The vegetation should be thoroughly dry. A light wind will help to carry a quick burning that will not damage the roots. Such burning is likely to aid grasses to crowd out annual weeds and brush. Hand cutting of brush during the burning will likewise help.

In some areas live vegetation in drains has been burned with an oil flame. Usually the flame thrower is mounted on a truck or trailer and operated along the berm of the ditch (fig. 11). A high-pressure pump forces the fuel oil through the spray nozzles and a large flame covers the vegetation in the ditch. The first burning kills much of the green vegetation and stunts growth. A second burning about 2 weeks later does a more complete job because of fuel in the dry plant material from the first burn. You can wait longer before making a third burn.

The Imperial Irrigation District in California used burning for weed control on its 3,000 miles of irrigation and drainage canals for several years until 1948 when it changed to chemical methods of control. A typical burner included a rotary pump to maintain the oil pressure, a small gasoline engine to run the pump, and a set of 4 to 6 spray nozzles. The spray nozzles were attached to the end of a 15- or 20-foot swinging boom. The counter-balanced boom could be swung easily to any position to burn off the bottom and sides of the ditch. The burning unit could be mounted on planks and removed from the truck when not in use.

In 1946 this district operated 10 truck units. It burned 18,000 miles of ditchbanks at an average cost per burning of about $10 a mile. It took several burns a year for some ditches. Such a burner is too large for most farms but may be practical for a drainage or irrigation district with many miles of ditches. A satisfactory road along the ditch is essential.

Smaller burners suitable for individual landowners or small drainage enterprises were used by sugarcane growers in Louisiana (fig. 11). Sim-

TABLE 1.—*Guide for use of chemicals on common ditchbank weeds*

[furnished courtesy L. S. Evans, formerly Agronomist, Weed Investigation, U. S. D. A.]

Action [1]	Chemical compound or derivative	Treatment [2]	Normal dosage per acre	Remarks	Effect of chemical on representative species [3]	
					Can control—	Does not affect—
Selective herbicides	2,4-D	FS	1 to 4 pounds in 200 gallons water.	Ester formulations (in oil) more effective on "hard-to-kill" species.	Cattail, elderberry, morning glory, poison ivy, willows, sumac, honeysuckle.	Evergreens, ground cherry, ash, hickory, maple, oaks, raspberries, most grasses.
	2,4,5-T	FS	2 to 4 pounds in 200 gallons water.	Ester formulations (in oil) often preferred for woody plants.	Sweet gum, osage orange, some oaks, elm, maple, blackberry, hickory, ash.	Selectivity on most species not yet established.
	Mixtures of 2,4-D and 2,4,5-T.	FS	2 to 4 pounds in 200 gallons water.	Combinations are more effective against mixed stands of woody perennials.	A majority of woody and herbaceous perennials.	Most grasses.
Nonselective herbicides (contact).	Oils (diesel)	FS	150 gallons	Special weed killing aromatic oils are more toxic than diesel (see fortifying agents below).	Kills top growth of most weeds.	Sweet fennel, yellow star-thistle, mayweed.
	Pentachlorophenol.	FS	4 pounds per 100 gallons of oil. Spray to runoff.	Oil soluble form used to fortify oils or oil emulsions. Salt derivatives used in water or oil emulsion.	Kills top growth of most weeds and grasses.	Most perennials require several applications.

	Dinitrophenol	FS	1 1/3 pounds per 100 gallons of oil. Spray to runoff.	(See above)	(See above)	(See above).
	Ammonium sulfamate.	FS	¾ to 1 pound per 1 gallon water. Wet foliage to runoff.		Poison ivy and other shrubs.	Transient effect on perennial grasses.
Temporary soil sterilants.	Sodium-chlorate.	SA	600 pounds (Dry or spray application).	Fire hazard is less if applied in dry form.	Kills most weeds and grasses.	Whitetop, Camelthorn.
	Borax	SA	1800 pounds (apply dry).	Prolonged soil sterilization but slow initial kill because of low solubility. No fire hazard.	Kills most weeds.	Many grasses resistant. Mixture of 2 parts borax with 6 parts chlorate gets all species.
	Sodium-trichloroacetates.	SA/FS	100-200 pounds in 200 gallons of water.	1-3 months soil sterility. Can be used as contact killer.	Johnson grass, Bermuda grass, quackgrass, Para grass, most annual grasses.	Further trials needed to establish tolerant species.

[1] This classification is only approximate because certain chemicals can be used in more than one category by adjusting dosages.
[2] FS indicates foliage sprays applied to succulent young growth. SA indicates soil applications irrespective of stage of growth.
[3] Weeds listed in column "Can control" may require repeated applications—those listed in column "Does not affect" cannot be economically controlled. See USDA Farmer's Bulletin 2005 for more detailed list of species reaction.

FIGURE 11.—An oil-burning flame thrower drawn by a farm tractor being used for burning weeds in a small drainage ditch in Louisiana.

ilar burners have been used for weed control in other places.

The present trend is towards control by a chemical treatment instead of burning. When you do burn, do it so as not to injure crops that adjoin the ditches.

Chemical Control of Vegetation

The use of chemicals for ditch maintenance is a comparatively new practice. Some results have been good but others not so good.

If you are considering the use of chemicals for ditch maintenance, study the effectiveness, cost, and the possible damage they may do. Also, get detailed information on the kind of spray rig you need.

If possible, arrange for trials to see whether chemicals will do the job satisfactorily. Some manufacturers and distributors have cooperated in such trials.

Usually you need to apply more chemicals the first year than later. Applications at regular intervals are necessary for success. Trials carried out over one or two seasons give a good basis for estimating future costs. You need to study the use of chemicals before you can tell whether it will pay you to use them.

A disadvantage of chemical control is the chance of damaging adjoining crops or of poisoning livestock or fish. There have been some claims that fumes of esters of 2,4-D have drifted a half mile or more and have injured cotton. Some chemicals kill fish. Others burn or explode readily.

Control of ditchbank weeds

The chemicals used for the control of ditchbank weeds are described in table 1, prepared by L. S. Evans, formerly agronomist, weed investigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture.

Since 1945 the chemical 2,4-D and 2,4,5-T have been used widely. They are known as selective chemicals because they control most broad leaf and woody types of vegetation but do not permanently injure most grasses. Thus sod-forming grasses remain

to stabilize ditchbanks. Even minute quantities of 2,4-D, however, will kill or damage crops such as cotton, tomatoes, legumes, and many flowers, bush fruits, and truck crops. If you plan to use chemicals, consult Farmers' Bulletin 2005, Using 2,4-D Safely, or your State experiment station. Also get from your local dealer the latest recommendations furnished by chemical companies.

Sodium arsenite. Solutions of sodium arsenite have been used for killing all vegetation that it covers. But it is highly poisonous to livestock and for this reason is not recommended for use in drains.

Sodium chlorate. When this chemical spray dries the residue becomes highly flammable.

Spray rigs. Many kinds of spray rigs are available commercially. Liquid spray outfits usually include one or more tanks for the chemicals, a pump, an engine to drive the pump, a flexible hose or pipe, and nozzles to form a fine spray (fig. 12). The nozzles should be adjusted carefully for best results. You need to get a pump that will operate at the right pressure and capacity so the vegetation will be well covered with the chemical spray.

Spray equipment may be mounted in a truck or on a tractor and run along the ditchbank. Boats and amphibious vehicles have been used to advantage where water was deep enough.

Usually it is not practical to use an airplane for spraying ditchbanks because the chemical spray may drift and damage crops.

A knapsack sprayer carried on a man's back is adequate for trials and for most farm use. Such a sprayer holds from 3 to 5 gallons and costs less than $25.

FIGURE 12.—Chemical spraying to control vegetation in a drainage ditch in the Midwest. The hose is long enough to permit the operator to walk in the bottom of the ditch if necessary.

TABLE 2.—*Guide for use of chemicals in aquatic weed control*

Chemicals	Type of treatment or situation	Rate of application[1]	Principal weed species affected	Effect on aquatic animal life	Other side effects or precautions in use
SUBMERGED AQUATICS					
Aromatic solvents (See text for specifications).	Underwater spraying in flowing water. Treat before plants impede flow of water. Not suitable for static water.	300 parts per million (p.p.m.) for 30 minutes at initial station (4 gal. per cu. ft. per sec.). Booster shots at ½ mile intervals. Required dosage depends on species of weeds.	Pondweeds (*Potamogeton* spp.). Horned pondweed (*Zannichellia palustris*). Waterweed (*Anacharis* spp.). Various algae including *Chara* spp. Coontail (*Ceratophyllum demersum*).	Highly toxic to all forms.	Aromatic solvents are inflammable. Low toxicity to crop plants. Water temperature affects efficiency of emulsifiers. Loss of chemical due to absorption by plants and silt particles and evaporation when emulsion breaks.
Benoclor 3C	Underwater spraying in flowing water. For static water—use less miscible Benoclor.	300 p.p.m. for 60 minutes. Booster shots at ½ mile intervals.	Horned pondweed (*Z. palustris*). *Chara.* *Anacharis.*	Highly toxic to all forms.	Kills vegetation rapidly. Emergent species must be cut below water line. Imparts unpleasant taste to water but low toxicity to crop plants.
FLOATING AND EMERGENT AQUATICS					
2, 4-D	Boat-mounted sprayers or airplane application of concentrated sprays for large water bodies.	0.1 to 0.2 (percent foliage spray 2-4 lbs. active ingredients per acre).	Water-hyacinths (*Eichhornia crassipes.*) Pennywort (*Hydrocotyle* spp.) Waterprimrose (*Jussiaea californica*).	No direct effect of concentration prescribed. See next column for indirect effects.	Decaying vegetation causes temporary oxygen depletion in underlying water. Drift of spray or volatile fumes will damage nearby sensitive crops.
General contact sprays: Oils. Fortified oil emulsion. Dinitro compounds. Ammonium sulfamate.	Contact sprays must cover and wet the foliage. Wetting agents aid in getting complete coverage.	Dosage will depend on material and species involved—usually 100-150 gallons per acre.	Top growth of most species destroyed. Perennials will require several treatments e.g. cattails (*Typha* spp.) and tule (*Scirpus* spp.).	None at usual weed killing dosages.	For use against species resistant to 2,4-D or where 2,4-D drift endangers adjacent field crops.

[1] These rates are guides only and should be adjusted to meet local conditions and experience.

Control of aquatic vegetation

Plants that normally grow beneath the water, such as pondweeds, mosses, and waterweeds, may be controlled by aromatic solvents or by a chemical known as Benoclor-3C (table 2). These chemicals are poisonous to fish.

Such chemicals may be sprayed or dissolved in flowing water at intervals along the ditch. Enough solution is applied at one location to give a high concentration up to 300 parts per million (p. p. m.). The equipment used is then moved downstream to where the solution thins out and reaches say 150 to 200 p. p. m.

Field trials have indicated that enough solvent naphtha should be applied to reach a concentration of 185 p. p. m. for 1 hour. An emulsifying agent, such as mahagony soap, 5 percent in volume, is needed. Petroleum solvent naphtha is highly inflammable and must be used with care to avoid flash explosions and fires.

Benoclor-3C forms a white emulsion that sinks to the bottom of the channel. A concentration of Benoclor-3C of 300 p. p. m. for 1 hour or 150 p. p. m. for 2 hours, has been recommended. This amounts to about 6 gallons of chemical per hour applied to a ditch flowing 1 cubic foot per second. It is most effective when applied in the spring before the vegetation gets above the water.

Chemicals can be used to control floating weeds and those which emerge from the water (table 2). Some aquatic plants such as hyacinths have been brought under control with chemicals only to be succeeded by other water weeds just as bad. It is well to know through trials what will happen when chemicals are used regularly.

Mechanical Control of Vegetation

Heavy equipment of several types is available for the removal of vegetation. For most drainage work, silt is cleaned out along with the vegetative growth. Draglines are sometimes equipped with rakes or special buckets to clean out the vegetative growth.

Equipment using a continuous bucket has also been effective. Floating dredges have been used to remove hyacinths and floating vegetation from large channels. Small boats have been equipped with underwater weed cutters for control of submerged vegetation.

In some places in the West, plants are controlled by pulling a heavy chain along the bottom and banks of a ditch. The chain is pulled by tractors or teams working on both ditchbanks. This method gives good results in control of submerged aquatic weeds such as tules, cattails, burreed, and arrowhead. The weeds pulled loose should be caught by a screen and removed later with pitchforks or by a tractor equipped with a hoist.

Cultivating Equipment

Where you can do it, the most practical way to maintain field drains is through your regular cultivation. You can plow out shallow drains with a turning plow or disk plow, or use a tractor and grader. The plow does a better job on ditches having

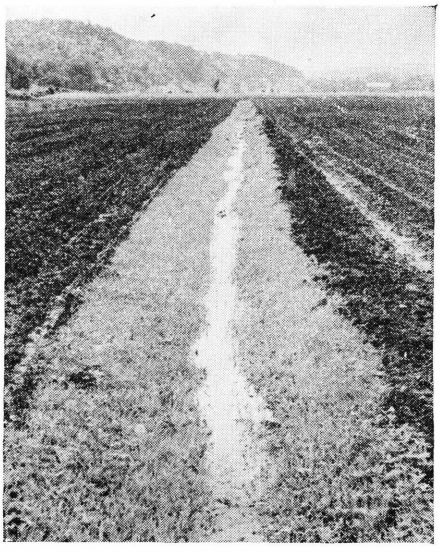

FIGURE 13.—Well-vegetated shallow field drain in Virginia that can be maintained with regular farm equipment.

a flat side slope such as 5 to 1. Loose soil should be cleaned from field drains after cultivation.

Correct plowing and proper grading of fields is important to improve field drainage (pp. 4-5). Floats and land levelers probably will be used more and more to grade drained land.

Tractors and Attachments

Tractors are one of the principal tools for maintaining all sizes of drainage ditches. With suitable attachments, tractors may be used for ditch work when they are not otherwise in use.

As much maintenance as possible should be done with farm tractors (fig. 13). Turning plows, disks, and scoops can all be used to remove the silt from flat-bottom ditches.

For overhauling a system, or for a major maintenance job, renting a large tractor from a contractor may be economical. Caterpillar types of tractors (usually of more than 50 horsepower) equipped with graders, bulldozers, or carry-all scrapers, are effective.

These large tractors are used mostly on ditches not more than 30 inches deep that have side slopes of 3 to 1 or flatter. Costs for rehabilitation run from $100 to $300 a mile, depending on the size of the ditch, working conditions, and local rates. If a tractor mires down on a wet drainage ditch it adds to the cost.

Tractors and 6- to 8-yard carry-all scrapers have been used successfully in such places as the Red River Valley in North Dakota and Minnesota (fig. 14) and in Alabama. Dirt may readily be dumped in depressions to improve field drainage. They are also effective for maintaining the wide field ditches that are required where large combines are used. These ditches range in depth from 12 to 30 inches and have a bottom width of at least 6 feet. Such ditches may also be maintained with a disk plow.

Carry-all scrapers may also be used to shape a V-type drain. They are especially useful in fields having undulations that limit tractor-and-grader work.

Tractors having dragline boom attachments have been used effectively for ditch maintenance, in Louisiana for example.

Tractors equipped with a bulldozer blade or pulling a grader are often used for leveling spoil banks following ditch excavation (fig. 15).

By reversing the bulldozer blade and providing enough clearance between the tractor and the blade, you have a tool that can pull away from a ditch. With this tool you can pull

FIGURE 14.—Wide bottom field lateral commonly used in North Dakota and Minnesota. The side slopes are 4 to 1 and the spoil banks are leveled to permit easy crossing with combines.

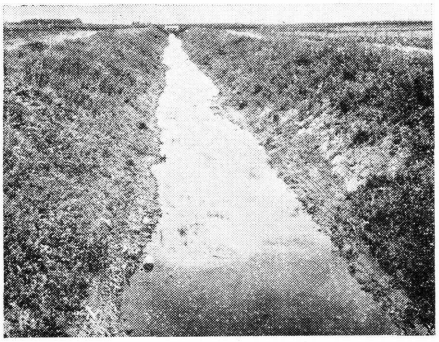

FIGURE 15.—Spoil banks on this Iowa outlet ditch leveled so that they can hardly be noticed. The ditchbanks were seeded to a grass mixture.

down spoil banks, remove brush and stumps, or remove silt from shallow drains that are too wet to cross.

Tractors have been used with single or double drum hoists to pull small slip scrapers out of the ditch. The scraper is then returned by hand or by a return cable. Crescent or slip scrapers have also been used on a direct pull. The tractor moves away from the ditch and pulls the loaded scraper out of the ditch. Then the tractor backs up and the scraper is pulled into the ditch by hand.

These various attachments have been used with light tractors for maintenance jobs, but they are not now of major importance. The cost of moving dirt by such attachments is usually more than if done with a dragline, blade grader, bulldozer, carry-all scraper, or plow.

A promising method of ditch maintenance was used by A. R. Wrather, a landowner near Portageville, Mo. With a 66-horsepower caterpillar-type tractor equipped with an angle-dozer blade he cleaned his ditches of vegetation and at the same time resloped the ditchbanks.

Starting at the top of the ditchbanks, the angle dozer widened the ditches, flattened the side slopes, pushed out brush, and leveled and smoothed shoals in the bottom. The tractor generally operated parallel to the ditch. The tracks of the tractor were kept tight and the ditch was dry.

Originally the ditches were 5 to 8 feet deep and 6 to 10 feet wide at the bottom. Side slopes were about 1½ to 1. The banks and bottom were covered with brush and 2-year-old willows. The finished ditches had **2½-to-1** side slopes and were clear of brush and vegetation. They were wider at the top and narrower at the bottom than before the maintenance work.

Mr. Wrather's cost, allowing $10 an hour for the machine, was about $100 a mile. Currently hand cutting, piling, and burning brush on similar ditches in his locality costs about $300 a mile.

Patrol Graders

Road patrols or patrol graders can be used for maintenance of drainage ditches. Machines with a 4-wheel drive are well adapted to ditching work. One of the drive wheels can ride on the berm and provide flexibility in cleaning out the ditch. Road patrols can handle about the same class of work as a tractor and grader. Ordinarily they are used on ditches not more than 30 inches deep.

Dragline Excavation

For many years the dragline excavator (fig. 16) has been the machine most widely used for cleaning out drains as well as for digging them. Draglines commonly used for drainage work range in size from ⅜ to 2½ cubic yards. They are usually owned and operated by contractors. Contractors may be found in nearly every locality where there is drainage work.

Prices for clean-out work generally range (September 1952) from 12 to 25 cents a cubic yard where 5,000 to 50,000 cubic yards are excavated; the lowest prices are usually for the largest jobs. Such prices do not include clearing trees and removing large stumps and may not include spoil-bank leveling. Prices quoted on specific jobs may

FIGURE 16.—Dragline excavator enlarging a drainage ditch.

vary greatly depending on the size of the job, cost of moving equipment, difficulties in handling stumps and dirt, and other factors.

When you engage a contractor to do dragline excavation work, you will get best results if you have a competent engineer plan the job, stake out the work accurately, and measure the completed ditch section. Important contracts are usually let on a basis of cost per cubic yard with an estimated yardage stated in the contract. A contract based only on price per lineal foot of ditch or a lump-sum bid for the job may cause misunderstanding between the contracting parties.

If your ditch has a good grass sod on the ditchbanks, do not disturb it any more than necessary. Bank vegetation may be protected by a "bottom clean-out" if the ditch is wide enough at the top. Some ditches can be enlarged by working only one bank. The other bank can be left undisturbed.

A special type of dragline ditching excavator (fig. 17) has been used with success in Louisiana and other States for constructing and maintaining small ditches. This machine uses a bucket shaped to maintain uniform side slopes. A continuous forward movement is obtained by a "creeper attachment." As one bucket load is being dumped the machine moves forward in position to start loading the bucket. The machine can spread the removed silt over a wide area.

In a 10-hour day, this machine can clean out from 3,000 to 5,000 feet of ditches averaging 30 inches in depth. Contracts were let for from $100 to $140 per mile (1952 costs). Clean-outs are required at intervals of 3 to 5 years.

Teams and Scrapers

Where teams are available, slip scrapers may be used for cleaning out shoals and bars. You may also use teams for removing trees or brush that obstruct ditches.

One method of cleaning ditches with

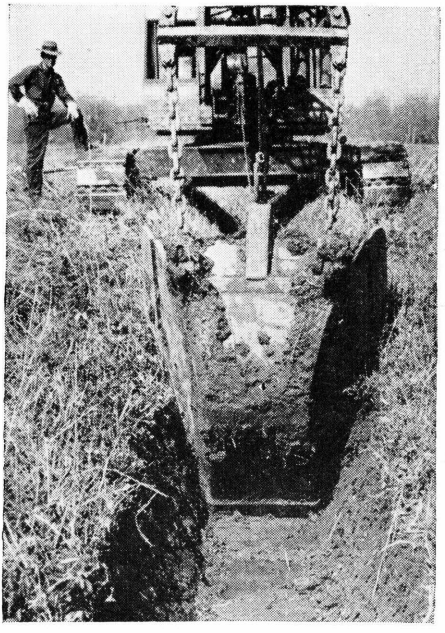

FIGURE 17. — Close-up of the shaped bucket used with a dragline made specially for constructing and maintaining narrow ditches. The machine is designed to straddle the ditch and to spread the removed silt over a wide area.

FIGURE 18.—This excavator is truck-mounted and may be transported readily for small jobs. The boom maintains uniform ditchbanks.

teams and scrapers is to cut inclines in the ditchbanks about 200 to 300 feet apart. Teams enter at one incline, load the scraper in the ditch, and pull out at the next incline. Teams can work in wet fields in cleaning out field ditches after heavy rains.

Special Equipment

Many areas where large mileages of small ditches need periodic maintenance could be well served by special excavating equipment that involves a bucket or blade for moving dirt. Excavators with a wheel, continuous buckets, or with a stiff boom (fig. 18) secure a uniform ditch section.

The dragline with side-arm attachment is used in England but has been used only experimentally in the United States. It removes earth from the bottom of a ditch without disturbing the side slopes. The ordinary dragline usually tears up much of the sod on the side slopes when cleaning silt out of a ditch bottom. The side-arm attachment permits the dragline bucket to be pulled along the ditch bottom in the line of the ditch.

An excavator equipped with a clam shell bucket may be used for a bottom clean-out especially in sandy soils.

Dynamite for Cleaning Ditches

Dynamite may be used for ditch blasting and for removal of shoals and bars in a ditch (figs. 19 and 20). It is economical when used under the right conditions and can easily be transported for isolated or small jobs.

Dynamite is well adapted for wet and unstable soil conditions where machine work would be costly and for drains less than 4 feet in depth. It is hard to blast dirt out of deep drains having steep side slopes.

FIGURE 19.—A drainage ditch completely filled with brush.

FIGURE 20.—The same ditch after it was cleaned out with dynamite.

If you plan to use dynamite you should get an experienced blaster to teach you how to use it. State and local regulations covering safety requirements for storage and use should be complied with. Often there is no need for you to become a proficient blaster because you can hire experienced blasters at a reasonable cost locally. Many fatal farm accidents have resulted from improper use of dynamite.

Safety measures include isolated storage of dynamite in specially constructed boxes or houses. Separate small storage boxes should be provided for blasting caps, which are especially dangerous. Caps and dynamite should be kept locked up until you are ready to use them. Distributors or manufacturers of dynamite can often arrange to do such work, or they can supply the dynamite and caps when needed. They can also usually supply detailed information relating to use of dynamite for ditch work.

Farmers' Bulletin 2046, Farm Drainage, also gives information on using dynamite for blasting drainage ditches.

Structures in Outlet Ditches

Floating debris such as logs, limbs, and cornstalks at bridges, culverts, water gates, and fence crossings (fig. 21) should be removed promptly after rains. This is necessary so as not to obstruct the flow in the ditch and also for safety of the structure.

If the silting at a culvert is rapid it may not be possible to maintain the required openings. Then it may become necessary to build a bridge or a larger culvert.

Water gates may sag or the ditch may silt up so much that the gates cannot open when the water rises. Their maintenance includes tightening the cables or otherwise raising the gates, or removing obstructions from the ditch.

Many fences are installed that block public ditches at bridges or at fence crossings. Hogs allowed in ditches cause much damage. Poorly built farm bridges and small culverts interfere with the flow of water. The governing

FIGURE 21.—Debris collecting on fence has partially obstructed this ditch. This fence should be replaced by a water gate.

body of a public drainage enterprise usually has the authority to deal firmly with any unauthorized uses and with the placing of obstructions in public ditches.

A maintenance program may require the installation of small protective structures that were overlooked during construction.

Sod flumes are needed in some spots to drop water from the field level to the outlet ditch. It may be necessary to wire sod in place or to divert water around the flume until the sod becomes well established.

Corrugated iron and other types of pipes are used in many places for the same purposes. Drop-spillway dams, though expensive, are effective in controlling erosion at points where field drains and laterals discharge and where ditch grades are steep.

Streambank Protection

On streams that flow into the drainage system, streambank protection may be needed as a part of annual maintenance work. Vegetation is an economical method of controlling bank erosion and should be used where practical. Often mechanical control is also needed. Where the problem is serious, assistance of specialists in this kind of work is usually needed. Leaflet 258, Streambank Plantings for Erosion Control in the Northeast, gives information on how to protect streambanks in the Northeast.

Keeping Tile Drains Working

Compared with open ditches tile drains take little care, if they are properly installed in the first place. But since a good tile drainage system often costs $75 or more an acre, it is simply good business to keep it working efficiently. In other words, you need to protect your investment.

You should watch the outlets to see that poor maintenance of outlets does not cause silt to back up and clog your tile line. Clean your silt wells when they need it. Use your inspection wells and learn the signs of a blocked tile line to know where your system needs repair. Other than this, about all

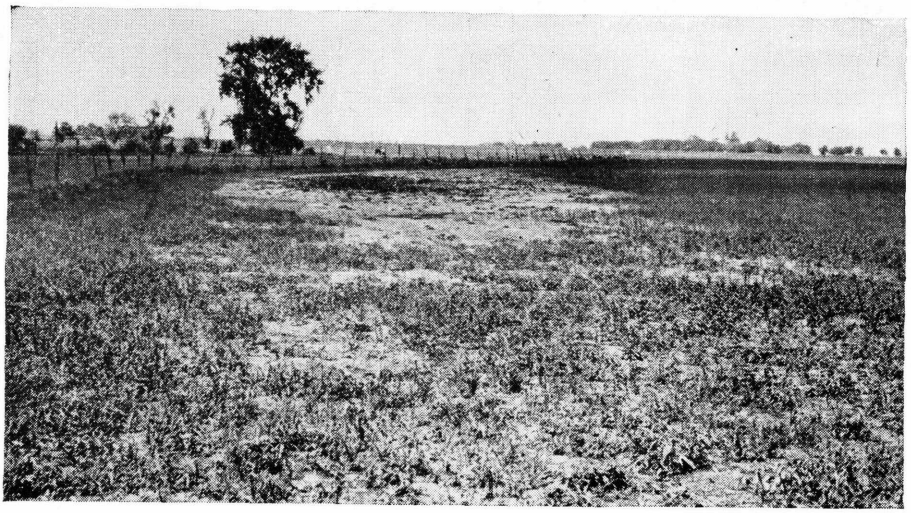

FIGURE 22.—The wet spot is a warning that the tile may be stopped up.

you need to do is to follow a crop rotation that keeps your soil in good tilth.

Once a system is not working right, about the only remedy is to dig up tile and make the needed repairs. Sometimes a system gets in such bad shape that the most practical thing to do is to relay it. Then it should be redesigned in accordance with modern engineering standards. (See Farmers' Bulletin 2046, Farm Drainage.)

When a tile drainage system is working satisfactorily, water stands in the field for only a short time after heavy rains. But when tile drains become even partly blocked, water may remain in low areas for several days. Even if no surface water stands, a wet spot remains at the surface just above the stopped-up tile (fig. 22). Locating these spots can save a lot of digging.

Causes of Failure

Tile systems fail for several reasons. In one area in Ohio, 165 clay tile systems were repaired in 3 years, 1936-38. Most of these had been laid 30 to 40 years before. Here is a tabulation of the cause of failures of these particular systems:

Improper design—28 percent
- Tile too small, or not enough tile
- Cover over tile not deep enough
- Not enough surface inlets, catch basins, and outlets

Poor maintenance—28 percent
- Line filled with silt from openings
- Washed-out catch basins and surface inlets
- Root growth
- Tile not kept open

Poor construction—23 percent
- Poor joints
- Bottom not shaped to fit the tile
- Uneven grade
- Careless backfilling
- Poor junctions to laterals
- Poor alinement
- Improper laying in sandy soil, quicksand, or muck

Poor tile—21 percent

Other causes, not counted
- Sealed joints
- Stoppage by animals

Concrete tile laid in strong alkali or acid soils are apt to fail. This is especially true in soils with a high sulfate content and in peat. If you have concrete tile that has disintegrated, check your soils. You can get information about your soil and about resistant tile from your soil conservation district.

One of the most common causes of failure of a tile system is an outlet ditch that is too shallow. Except during bad storms, there should be a free flow of water from your tile outlet into the outlet ditch. If your outlet ditch silts up, water is apt to back up into the tile. Rapid silting usually follows. Roots of water-loving trees frequently penetrate between the joints of tile and stop up lines. So do sugar beets, arrowweed, hops, and grapes.

Roots from an elm tree 15 inches in diameter and 30 feet away stopped up a 15-inch tile line in Ohio. The tile was 4½ feet deep in loamy clay. The roots extended for 75 feet into the tile and almost completely filled the tile for 35 feet.

An apple tree completely clogged an 8-inch tile line, also in Ohio. The tree was 8 inches in diameter and located close to the tile, which was laid 4½ feet deep in clay soil.

A 10-inch tile line laid 3.1 feet deep in gravelly clay soil contained enough roots from small elders to reduce its capacity by one-half. The elders were some 4 feet from the tile line and none was more than a half inch in diameter.

Water flowing under too much pressure may lead to blow-out holes over tile lines. This can be prevented with a tight section of pipe, joint protection, or relief wells.

In some fields tile lines cease to drain land because the joints have sealed up. This may be due to soil puddling around the joints or to deposits of chemicals at the joints. Some have sealed by deposits of lime similar to those in limestone caves. Others have been sealed by iron deposits. The soluble iron that is in the ground water oxidizes on reaching the air at tile joints.

Animals getting into tile cause some tile stoppages. A swinging gate or wire screen over the tile outlet protects lines against animals.

Construction work or the laying of underground pipes and cables may break tile. This, of course, requires replacing.

Wash-outs are common where the gaps between tile are too wide or where these gaps are not protected so as to keep soil from washing into the tile. They are more likely to occur in sandy and silt loam soils than in heavier soils.

Locating Stoppages in Tile Drains

Many well-designed tile systems have inspection wells, silt wells, or manholes where flow in the tile may be seen. After heavy rains, watch these and the outlets to check the amount and the time of flow. When either changes it may indicate stoppage some place in the system. Usually it is easy to find if you know your system and your soil.

You should have a map of your drainage system. Then when you suspect a stoppage you can take a copy of the map to the field to help you locate the stoppage.

Unfortunately many tile systems were installed but no map showing location of tile lines and no record of size or of grade were kept. Sometimes an available aerial photograph will show the location of your tile drains.

Many special devices to locate lost drains have been tried—mine detectors and radar equipment, for example. But none has yet proved practical. The only practical way to find a tile once lost is with a sounding rod, with a soil auger, or by digging.

A ½-inch steel rod, at least 5 feet long, with a ¾-inch diameter steel ball welded to one end makes an effective sounding rod (fig. 23). These rods are effective for locating tile drains in many soils. While the rod is being pushed downward, pour water into the hole frequently to make the work easier. Sounding rods cannot be used in some soils, especially those with hardpan or gravel, and digging is necessary.

When the tile line has been located, drive stakes or markers over the tile. After the first two markers have been set, the rest of a tile line can be located more easily.

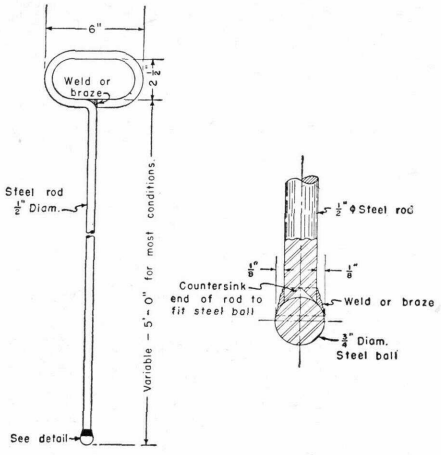

FIGURE 23.—A probe or sounding rod for locating tile drains.

Where you need to check on a long tile line, dig inspection pits every 100 to 250 feet. If the tile has a good flow of water, this distance can be increased.

You may be able to find obstructions between pits with a flashlight and a mirror.

If the line appears partly filled, pour water in the upper pit and check the time needed for the water to flow to the next pit. Block the next tile line upstream during the test. If the tile is more than half full of water flowing sluggishly, probably the line is partly blocked. If the tile has a small flow, color the water at the upper end with bluing or a dye and note the time it takes to reach the lower pit.

A general guide for such tests is that water should move through a 4- to 6-inch tile, flowing full, at about 1 foot per second when laid on a grade of 0.1 to 0.15 feet per 100 feet; flowing part full, somewhat slower.

If after digging several pits you find your tile system is in such poor condition that it needs extensive repairs or relaying, you will probably need an engineering survey. Such a survey should provide profiles of the existing tile system and of the topography of the land. It will furnish the right information for deciding what tile repair or relaying you need to do.

Repair of Tile Drainage Systems

The methods of repair to a tile line depend on what you find to be wrong and how serious the damage is. A break of a tile may require only the locating, digging up, and replacing of the bad section of tile.

Many tile drains have been installed with no protection for the outlet of the tile line, or with a poorly constructed outlet. This causes wash-outs at the end of the tile line.

Repair wash-outs at the end of a tile line by installing a well-designed headwall (fig. 24), or a pipe (fig. 25). Use a headwall if a large quantity of surface water is to be handled. An outlet pipe is cheaper and is satisfactory if the surface water will be handled at another location. The pipe should stick out over the ditch far enough so that the flow will not erode the bank.

When a line is stopped with roots you will usually need to dig up the tile and remove the roots, then relay the tile. For future protection remove all trees within 50 to 100 feet of the tile drain. Or, if you do not wish to remove the trees, lay a water-tight

FIGURE 24.—Tile headwall to protect the end of the tile line and surface water from a lateral to a main outlet safely. Sod protects the bank of the outlet.

line close to them. You can secure a tight pipe line by using a bell-and-spigot sewer pipe, by sealing the joints, or by using water-tight metal, asbestos, or bitumen-impregnated pipes. Tight pipes, of course, do not provide drainage; they serve only as underground channels.

If the tile is only partly filled with sediment or roots, you can use extension-type sewer rods for cleaning it. Some tile lines can be flushed clean with a large flow of water.

If the tile is almost filled with sediment (fig. 26), relaying is necessary. Relaying of tile is also necessary, as a rule, when the line is shallow or when many tile are broken.

Find out whether it is cheaper to dig up and reuse old tile or to install a new line. Generally it is not economical to salvage tile 6 inches or less in diameter. Salvage of good tile 8 inches or more in diameter is usually economical. If most of the tile are cracked or broken, it will usually pay to lay a new line.

Usually it is not practical to relay tile in an old trench, because of wet soil and the amount of hand excavation required. Ordinarily the new location should be several feet away. In relaying tile mains, be sure to find and connect all laterals.

Blow-out holes over a tile line can usually be repaired by installing pressure-relief wells where the tile changes grade abruptly. A relief well may be built by inserting a T in a tile line and connecting a pipe to the ground surface. It may be necessary to cement or protect the joints or to lay a tight pipe in the sections of the line causing trouble.

Few tile systems can handle all the excess rainfall during heavy storms since most of them remove less than ½ inch of water in 24 hours. To relieve the tile line, it is advisable to construct shallow surface drains and grassed waterways. Such waterways should be located to one side, not directly over a tile line.

Little or no water enters some tile lines. This may be because of poor soil structure or a tight soil condition. Both can be improved with a conservation crop rotation. Deep-rooted legume crops will open up some tight subsoils.

FIGURE 25.—Pipe outlet to protect the end of a tile drain and drop water into an outlet ditch without eroding the ditchbank.

Where joints are sealed, it may be possible to increase the spacing between joints. For example, to increase the spacing between tile by ⅛ inch, remove seven tile, cut 1 inch off of one tile, and relay the seven tile. Shortening a tile can be done by careful chipping or with a masonry saw. Sometimes you can buy short lengths.

To prevent the joints from sealing again, the relaid section should be backfilled with pea-sized gravel or with topsoil. Sections might be removed where water is ponding or every 30 to 80 feet along a tile line.

Working Out a Plan for Maintenance

You need a well-organized plan of maintenance whether your drainage system is in a drainage enterprise or-

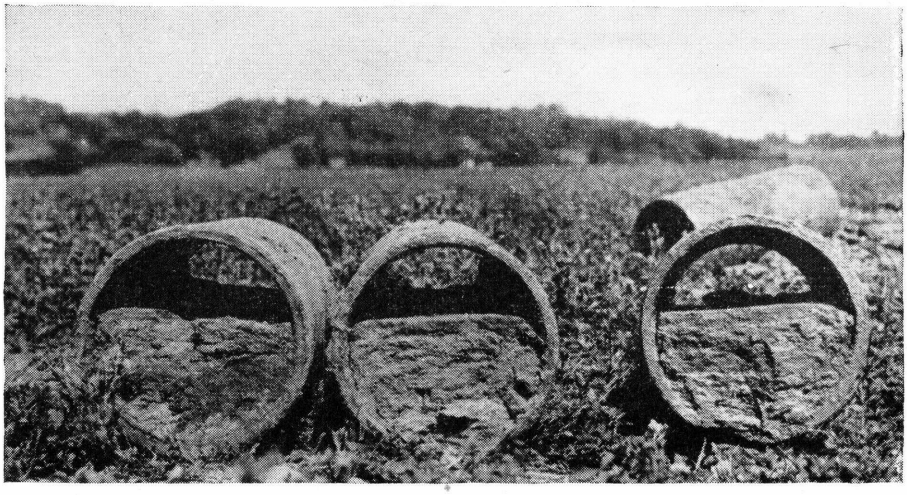

FIGURE 26.—A 12-inch tile line dug up in Illinois, almost completely filled with silt.

ganized under State laws, in an informal group enterprise, or all on your own farm. Good maintenance plans pay dividends in increased crop yields and reduced rehabilitation costs. Also remember that a conservation plan for your farm goes hand in hand with good drainage maintenance.

Soil Conservation District Assistance

Most of the farms and ranches are now in a soil conservation district. These districts have been organized by farmers and ranchers throughout the country since 1937. Where drainage is a problem, soil conservation districts are furnishing technical assistance in farm-drainage and group-drainage work. Most group plans include plans for the rehabilitation of drainage systems and for maintenance of drainage systems following reconstruction. The districts assist individual farmers and groups of farmers by preparing farm conservation plans. The group or the farmer pays the construction costs and is responsible for maintenance.

Some soil conservation districts encourage better maintenance through inspection by qualified technicians. Such inspections help judge the success of past work or determine the need for more work. Soil conservation districts sometimes assist by working out plans for maintenance and giving advice on procedures and methods needed to carry out maintenance work for group enterprises.

Maintenance in Drainage Enterprises

Within a group drainage enterprise it is often difficult to get simple types of maintenance work done on the group outlet drains. Many of the members do not recognize the need for maintenance until after crops have been damaged. Also the average farmer has so much work to do on his own farm that he has little time for outlet-ditch maintenance.

Drainage enterprises that have carried out successful maintenance work have nearly always obtained the services of skilled engineers. The work of these specialists includes preparing plans and specifications, setting grade and alinement stakes for contractors, measuring quantities of dirt moved, and making sure that the work has been done in accordance with the contract.

Most drainage enterprises have found it more economical to have excavating work done by contractors in

the dirt-moving business than with their own equipment. It may not be practical to contract other kinds of work, such as annual clearing and maintenance of structures.

Where several drainage districts are located close to each other they may pool their money for maintenance. One central location having offices for the engineer, repair shops for equipment, and yards for storing trucks, tractors, and draglines can result in saving money for each of the districts. With this set-up they can own, operate, and maintain their own equipment.

Management of equipment is a full-time job for a competent person who knows equipment, can anticipate the need for parts, and be on the job to keep the equipment running. Unless experienced management can be obtained by a drainage enterprise, contract work may be more economical.

Sound business requires setting up a plan of maintenance and budgeting funds for such work one or more years in advance. This is especially true if annual assessments for maintenance vary with the needs. In this case, the procedure will depend upon the State law under which the drainage enterprise is organized.

Drainage enterprises often find it difficult to carry out adequate maintenance programs because of inadequacies in State laws. If the responsibilities of the governing body of the drainage enterprise are not clear, or if a few individuals can delay or prevent an adequate maintenance program, it may reflect serious defects in the State law or in its administration. These difficulties may indicate a need for amending such laws.

A trend towards larger and more effective drainage organizations depends on the willingness of landowners to change to a new system of maintenance. Usually State laws would need amendment before such consolidations can be legal.

Some county governments also carry out regular maintenance. Many persons favor maintenance of group drainage enterprises on a county basis similar to the maintenance of county road systems. This would have the advantage of unified responsibility and authority for maintenance. They ask, "If counties can maintain the highways why not the lowways?" Necessary work could be carried on by a skilled force of machine operators or by contract. Efficient equipment could be purchased and serviced.

Here is a way one State has worked out a solution for drainage outlets.

In Louisiana a State-wide drainage program was begun in 1941. State aid is provided to the parishes that agree to construct and maintain a good system of outlet ditches. (In Louisiana the parishes are the same as counties of other States.) Engineering assistance is provided by the State Department of Public Works. This program has great promise as a means of maintaining outlet ditches. The following is quoted from the 1949 Biennial Report of the State of Louisiana, Department of Public Works, 1948-49.

> Previously drainage works in the State have been constructed by small drainage districts without any particular regard for the capacity of the outlet streams which received the drainage discharge; without regard for the effect of the small local improvement on surrounding areas; without any provision for adequate maintenance; and with high interest rates on bonds.
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> The State-Parish program is carried out in this manner:
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> 1. The parish police jury passes a formal resolution requesting that a survey and estimate of cost of the drainage needs of the parish be made by the Department.
> 2. The preliminary survey is made by the Department in collaboration with the police jurors, and an estimate of the cost of the new work, total obligations of drainage districts, and annual amounts required for maintenance is prepared.
> 3. If the police jury decides to go ahead with the work as estimated, election is called for a bond issue to take care of the parish's proportion of the cost and for an annual tax for maintenance.
> 4. If these propositions are voted upon favorably, construction proceeds under contracts let by the police jury with engineering and supervision of construction by the Department of Public Works.
> 5. Maintenance of completed channels on a parish-wide basis is provided by the police jury through use of the maintenance fund.

Maintenance Plans for Informal Group Enterprises

If you are a part of a drainage enterprise operated by mutual agreement between landowners you need a written plan of maintenance. This is true even more than for formal groups. Without a written agreement you have few safeguards if your land and crops are damaged because some other person fails to do his share of the maintenance work. A written plan of maintenance that includes right-of-way easements will avoid much trouble. The maintenance plan should be agreed to before any construction work is done.

Some of the points that should be included in a maintenance plan for an informal group enterprise are: (1) Methods of maintenance, including annual cost estimates, for each part of the drainage systems; (2) the amount and the kind of work to be done by each member of the group, and the time at which the work is to be done; and (3) an estimate of the amount of money and services that will be required from each member of the group annually.

Money will be needed for work let out by contract. Landowners should consider carefully the amount of necessary clearing, excavation, and other work and the time at which it will be done so that labor and equipment needs may be fitted into other farm requirements. Occasionally at the time of construction a group can raise funds for the maintenance work that will be needed for several years.

A well-planned maintenance program will prevent misunderstandings and help insure success of informal drainage groups of this type. The success of such enterprises will depend largely on the ability of the officers elected to head the group. Soil conservation districts can often assist such groups in preparing and carrying out plans for maintenance.

Right-of-Way and Maintenance Agreements

Landowners in mutual associations and voluntary groups should get and record easements for the construction and maintenance of outlet drains in accordance with provisions of State laws. The easement should provide for access of equipment to such drains. Such easements are often given to the group, to a legal government subdivision such as a soil conservation district or a county, or to other landowners.

The easements should make clear that other members of the group may carry out maintenance operations if a landowner fails to do so. The recording of easements is important because ownership of a farm may change.

Some drainage systems have failed because of the lack of an agreement relating to rights-of-way. Owners have agreed on the original construction of a drain, but some have failed to carry out maintenance work. As a result, crops were drowned out because a lower owner would not permit the necessary clean-out work. Such problems can be reduced if adequate maintenance and right-of-way agreements are provided. Forms for right-of-way easements may be obtained through an attorney. Legal requirements for such easements vary greatly between States.

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